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BIODIVERSITY AND BIOGEOGRAPHIC RELATIONSHIPS OF SELECTED INVERTEBRATES FROM URBAN BUSHLAND REMNANTS, PERTH, WESTERN AUSTRALIA

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Abstract

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The results of a continuous pitfall trapping programme designed to collect ground-dwelling invertebrates on the Swan Coastal Plain, Perth, is documented. Of the groups identified to date (Arachnida, except Acarina and some Araneae, scolopendrid and scutigerid centipedes, cockroaches and baeine wasps), 181 species have been identified, indicating a rich assemblage. Average linkage clustering analysis (UPGMA) of similarity indices derived from species abundance data is presented for some groups, which show differing patterns in relation to vegetation and landform. Larger bushland remnants have higher species richness and abundance.

Introduction

The depletion of native vegetation during urbanisation in many regions of the world has had an obvious and deleterious effect on much of the original biota, raising concerns for the long-term welfare of not only individual species, but of entire ecological communities. The rapid growth of Australian cities since European settlement has led to large-scale clearance and degradation of substantial areas of pristine bushland such that concerns have been expressed over the long-term viability of constituent species.

Perth is the largest city in Western Australia and is mostly situated on the Swan Coastal Plain centred on a latitude of approximately 32°S. It experiences a predominately Mediterranean climate consisting of hot, dry summers and wet winters where more than half of the annual rainfall of 837 mm falls between June and August. The coastal heaths and woodlands of the Swan Coastal Plain and surrounding regions are recognised internationally for their high diversity of both plants (Marchant, et al., 1987) and reptiles (How and Dell, 1994). However, the taxonomic and biogeographic relationships of the invertebrate fauna of this area is generally poorly documented.

A survey was commenced in 1993 to describe and interpret the ground fauna, both invertebrate and vertebrate, of remnant urban bushland patches on the Swan Coastal Plain, a region characterised by a series of landforms of Pleistocene age and a diverse array of floristically rich vegetation types. We here present preliminary data on a selection of invertebrates, including predacious (arachnids and centipedes), detrivirous (cockroaches) and parasitic (baeine wasps) groups, and examine the distribution of some species, their probable origins, and the biogeographic significance of these groups on the Swan Coastal Plain. This work is seen as a necessary precursor to any investigation into the effect that urbanisation might have on the remaining biota.

Methods

During the present study, which is the first of a 3-year program designed to investigate 12 or more locations on the Swan Coastal Plain, a total of 15 sampling sites were selected from four locations. These were selected so that a broad array of soil type and vegetation communities were sampled representing locations on four major landforms, including the more recent dune systems of Bold Park in the west, to the sands and colluvial clays and gravels of Talbot Road Reserve in the east.

Two of the four sites in Bold Park (BP) are on the Spearwood Dune System. Site BP3 is a *Banksia attenuata/B. menziesii* low woodland over low heathland on a dune top. Site BP4 is a Tuart

Eucalyptus gomphocephala woodland in an interdunal swale. Sites BP1 and BP5 are low heathlands on the coastal Quindalup Dune System.

All three sites at Tuart Hill (TH1–3) are Jarrah *Eucalyptus marginata* open woodland with a *Banksia attenuata* and *B. menziesii* low woodland understorey over diverse heathland on pale brown sands of the Spearwood Dune System.

Three of the four Perth Airport sites (PA) are on quartz sands of the Bassendean Dune System. PA5 is a dense low heathland, PA7 is a winter-inundated *Melaleuca preissiana* woodland, PA8 is a low woodland of *Banksia attenuata* and *B. menziesii* over low heathland. PA6 is a mixed shrubland apron of the Spearwood Sand System over Bassendean Sands.

Of the four Talbot Road sites (TR), sites TR1 and TR4 are on quartz sands of the Bassendean Dune System. TR1 is an open woodland of Jarrah *Eucalyptus marginata* with an understorey of *Banksia menziesii* and low heathland. TR4 is a *B. menziesii* low woodland over a low heathland. TR2 is a Marri *E. calophylla* woodland over low heathland on laterite/clay soils. TR3 is a *E. calophylla* woodland over *Hakea lissocarpa* shrubland on quartz sands similar to TR1 and TR4.

The invertebrate fauna was sampled solely by the use of pitfall traps placed flush with the ground at each of the sites. Ten 2 litre plastic ice-cream containers set with approximately 400 ml of ethylene glycol were placed 5–10 m apart. They were covered with linoleum floor tiles set approximately 10 cm above the top of the container to exclude rain and leaves. The traps were cleared every 6 weeks for a 12 month period, and the samples stored in 75% ethyl alcohol until they were sorted in the laboratory.

Several target groups were selected for detailed identification (ordinal names follow Harvey and Yen, 1989), which included arachnids belonging to four orders (Araneae, Scorpionida, Pseudoscorpionida, Opiliones), centipedes belonging to two orders (Scolopendrida and Scutigerida), cockroaches (Blattodea) and the parasitic wasps of the tribe Baeini (Scelionidae). Several arachnid and centipede groups were excluded from the analysis due to uncertainties with species level identifications: these included all of the Acarina and several families of Araneae, such as the Gnaphosidae (Arachnida), and the Geophilida and Lithobiida (Chilopoda). The data matrix is presented in more detail in How et al. (1996).

Similarity between sites was calculated using the Renkonen Index from the Biodiv (1993) package.

$I = \Sigma_i \min(P_{ij}, P_{ik})$

where P_{ij} is the proportion of the ith species in the jth sample and P_{ik} is the proportion of the ith species in the kth sample. The derived matrix was clustered using the UPGMA method.

Results and discussion

A total of 181 species was collected and identified, comprising 103 spiders, 3 harvestmen, 4 pseudoscorpions, 3 scorpions, 6 scolopendrid centipedes, 1 scutigerid centipede, 34 cockroaches and 27 baeine wasps.

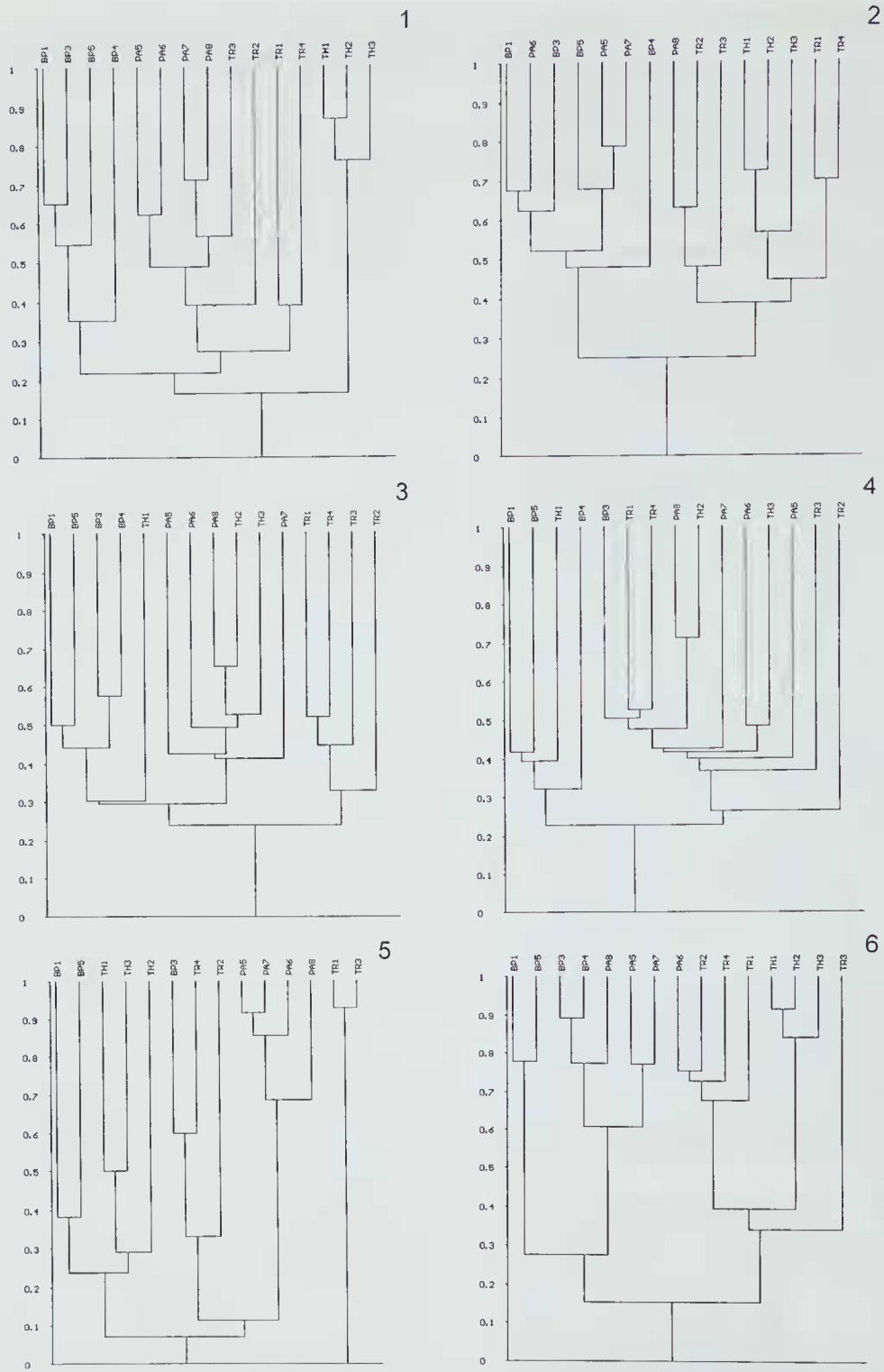
A total of 66 species (36.5%) was collected from only a single location and, of these, 34 species (18.8%) were collected from only a single site, although some of these have been previously recorded from outside of the study areas and should not necessarily be used to indicate extreme endemicity. For example, the pseudoscorpion *Geogarypus taylori* Harvey is widely distributed across much of southern Australia (Harvey, 1986), and yet was only collected at the four Bold Park sites during the present study. However, it has been taken from two other sites on the Quindalup dunes, Woodman Point and Mount Claremont, during later aspects of this study, and the species may be restricted to this dune system in the Swan Coastal Plain. The actinopodid spider *Missulena granulosa* Hogg was only represented by a single male from BP5, and yet is widespread in south-western Australia (based upon records in the Western Australian Museum). In addition, some predominately arboreal species were occasionally caught in the pitfall traps, and the apparent endemicity of these species is probably due to a form of sampling bias. For example, of the five species of Heteropodidae collected, at least one (*Isopeda leishmanni* Hogg) is known to be extremely abundant throughout the Perth metropolitan region and elsewhere in southern Australia (Hirst, 1992).

Our preliminary documentation of invertebrate biodiversity shows considerable variation in the total number of species recorded from each site, ranging from 34 species at TR3 to 71 species at BP1 (Table 1).

The 181 species identified from 16 sites at the four locations sampled were subjected to similarity analyses of their composite assemblages. Similar data for the Baeini were also evaluated. These data are preliminary in that the project intends to document assemblages from over 30

Table 1. Total numbers of species of selected invertebrate groups from four locations on the Swan Coastal Plain, Perth.

Location	Bold Park				Perth Airport				Tuart Hill			Talbot Road				
Patch size (ha)	338				400				9			90				
Site	BP1	BP3	BP4	BP5	PA5	PA6	PA7	PA8	TH1	TH2	TH3	TR1	TR2	TR3	TR4	TOTAL
Araneae	36	31	26	30	30	32	28	19	30	15	27	20	30	17	15	103
Opiliones	1	1	1	1	3	3	3	3	2	2	2	1	0	0	1	3
Pseudoscorpionida	2	4	2	2	1	1	1	2	1	1	1	2	2	0	1	4
Scorpionida	2	1	1	1	1	2	0	2	3	0	1	2	2	2	2	3
Scolopendrida	4	2	2	2	4	4	3	5	2	2	3	3	5	2	3	7
Scutigerida	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Blattodea	14	17	16	12	16	18	8	8	8	10	6	11	13	9	11	34
Baeini	11	9	6	12	13	6	11	6	12	9	10	12	9	4	6	27
TOTAL	71	66	54	60	68	66	54	45	58	39	50	51	61	34	39	182



Figures 1–6. Dendrogram of similarity between sites for selected invertebrates using the Renkonen Index on abundance data and UPGMA clustering. Locations are identified by the following alpha codes: BP, Bold Park (sites 1, 3–5); PA, Perth Airport (sites 5–8); TH, Tuart Hill (sites 1–3); TR, Talbot Road (sites 1–4). 1, cockroaches; 2, baeine wasps; 3, arachnids and centipedes; 4, all spiders; 5, mygalomorph spiders; 6, centipedes.

sites at 11 locations throughout the Perth area.

Some interesting biogeographic patterns are evident in the data. In many analyses conducted, the three Tuart Hill sites have high similarity (e.g. Figs 1, 6), possibly due to their close vegetational and geographic similarity, but this may also be due to the low species counts obtained at each site (see Table 1).

Cockroaches (Fig. 1). The 34 species of cockroaches indicated three major clusters. TH is different to all other locations but high internal similarity is due to the low number of species, most of which are widespread across all landforms and vegetation types. The four BP sites also group together, with the three heath and shrubland sites (BP1, BP3, BP5) more similar to each other than to the woodland site BP4. TR1 and TR4 are heath and shrubland sandy sites on the Ridge Hill Shelf landform and have different assemblages to the remainder of the TR sites, and to the heaths and shrublands at PA on the Bassendean Dune System which show little similarity within themselves.

Baeine wasps (Fig. 2). Analysis of a group of parasitic wasps, the Baeini (Scelionidae), collected during the survey showed very little concordance with either vegetation or landform data. This can probably be explained by their biology which is more likely to track their spider hosts (Iqbal and Austin, 1997). Spiders as a group have low similarity between sites (Fig. 4) and probably account for the Baeini pattern where neither geomorphic unit or vegetation type can account for the clustering (see below).

Arachnids and centipedes (Fig. 3). The examination of the entire arachnid and centipede assemblage documented thus far (120 species) indicates that there is low similarity between sites on either the same landform or those of similar vegetation type. Although BP and TR sites do form loose clusters, there is low similarity between them and with sites on the Bassendean Dune System (PA) or Spearwood Dune System (TH).

Spiders (Fig. 4). Being by far the most diverse (103 species identified thus far) and abundant arachnid group identified during the survey, the influence of the lack of assemblage pattern for either landform or vegetation type in this group will have influenced the cluster of Fig. 3 as well as Fig. 2. This lack of pattern can be explained by a number of factors, most importantly that spiders constitute a diverse assemblage with remarkably varying life history strategies and ecological attributes (Humphreys, 1988; Churchill, 1997). The mobility of individuals may vary greatly between species, thus affecting their capture rate during the survey.

Much of the observed clustering in several analyses conducted can be attributed to either the low species count, or to the overriding influence of spiders (103 species) on the pattern depicted. Some of the arachnid and centipede groups surveyed were represented by very few species. These include the **mygalomorph spiders** (Fig. 5), of which only 13 species were collected, and 8 of these were found at only a single location. Indeed, site BP4 yielded no specimens during the survey. Of the remaining sites, TR1 and TR3 clustered strongly with each other and they possessed no similarity with the remaining sites. This is mostly due to the very low species counts at these sites: only a single species was collected at TR1 (*Teyl* sp.) and only 2 species at TR3 (*Teyl* sp. and *Aganippe* sp. 2), with *Teyl* sp. not being represented at any other site and *Aganippe* sp. only being found elsewhere at TR4. Similarly, all of the PA sites clustered strongly but much of this can be explained by the high percentage of several common species.

With only 7 species collected, the **scolopendrid and scutigerid centipedes** (Fig. 6) represent another low-species group. However, many species were collected in large numbers, indicating a stronger signal in the analysis. The two sites on the Quindalup Dune System, BP1 and BP5, showed strong similarity to each other, as did the three TH sites. Three of the four TR sites clustered strongly with PA6, but the very weak linkage of TR3 with other sites is difficult to explain.

The results presented here clearly indicate that four urban bushland remnants situated on the Swan Coastal Plain, possess very high spider and cockroach diversities, with moderate diversities for the other groups sampled. The influence of landform was evident, but not paramount, in several analyses, with the most obvious link being the strong similarity of the two sites situated on the Quindalup Dune Systems (BP1 and BP5).

An understanding of the biology of species comprising assemblages and their response to pitfall trapping is crucial to an interpretation of similarity dendrograms. The reptile assemblages of 17 locations in the Perth region show differing responses to landform or vegetation type depending on the family considered (How and Dell, 1994). Skink assemblages from sites on the same landforms are more similar than are those

from similar vegetation types on different landforms, while snakes and other lizards show little patterning with either criteria and are probably poorly sampled by pitfall trapping (How and Dell, 1994).

A range of factors have not yet been fully considered in relation to the invertebrate ground fauna of the remnant bushland patches. These include the size of the remnant, its recent fire history, and other perturbation factors, such as weed infestation, grazing and logging. We estimate that the range of many species will be substantially increased as this study continues, and we will use the additional data to test the preliminary associations between sites found in the present study.

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